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DELAWARE UNIV NEWARK APPLIED MATHEMATICS INST

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DIRECT AND INVERSE PROBLEMS IN OBSTACLE SCATTERING FOR APPLICAT--ETC(U)

FEB 81 T S ANGELL, R E KLEINMAN

AFOSR-79-0085

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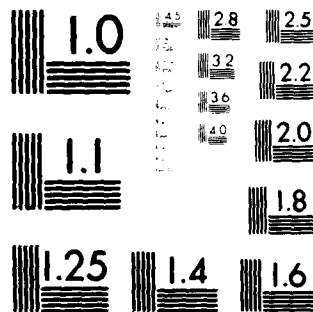
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19 REPORT DOCUMENTATION PAGE		READ INSTRUCTIONS BEFORE COMPLETING FORM
1. REPORT NUMBER <b>AFOSR-TR-81-0369</b>	2. GOVT ACCESSION NO. <b>AD-A098144</b>	3. RECIPIENT'S CATALOG NUMBER <b>11</b>
4. TITLE (and Subtitle) <b>DIRECT AND INVERSE PROBLEMS IN OBSTACLE SCATTERING FOR APPLICATION IN DETECTION, IDENTIFICATION AND COMMUNICATION</b>		5. TYPE OF REPORT & PERIOD COVERED <b>FINAL, Jan 79 - Jan 81</b>
7. AUTHOR(s) <b>T.S./Angell and R.E./Kleinman</b>		8. CONTRACT OR GRANT NUMBER(s) <b>AFOSR-79-0085</b>
9. PERFORMING ORGANIZATION NAME AND ADDRESS <b>Applied Mathematics Institute University of Delaware Newark DE 19711</b>		10. PROGRAM ELEMENT PROJECT TASK AREA & WORK UNIT NUMBERS <b>2304/A4 61102F</b>
11. CONTROLLING OFFICE NAME AND ADDRESS <b>Air Force Office of Scientific Research/NM Bolling AFB DC 20332</b>		12. REPORT DATE <b>FEB 81</b>
14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office) <b>Final rept. Jan 79 - Jan 81</b>		13. NUMBER OF PAGES <b>6</b>
16. DISTRIBUTION STATEMENT (of this Report) <b>Approved for public release; distribution unlimited.</b>		15. SECURITY CLASS. (of this report) <b>UNCLASSIFIED</b>
17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)		
18. SUPPLEMENTARY NOTES		
19. KEY WORDS (Continue on reverse side if necessary and identify by block number)		
20. ABSTRACT (Continue on reverse side if necessary and identify by block number) <b>Research was carried out in three main areas: constructive solution methods for integral equations arising in scattering problems; analysis of time dependent scattering phenomena; and applications of boundary control methods in radiation and scattering problems.</b>		

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**AFOSR-TR- 81 - 0369**

Direct and Inverse Problems in Obstacle  
Scattering for Application in  
Detection, Identification and Communication

T. S. Angell and R. E. Kleinman

Applied Mathematics Institute  
University of Delaware

Final Scientific Report  
January 1979 - January 1981

*AFOSR-79-0085*

Prepared under [REDACTED]

Submitted to

Air Force Office of Scientific Research  
Bolling Air Force Base  
Washington, D.C.

Program Manager  
R. N. Buchal  
Directorate of Mathematical and Information Sciences

February 1981

1. Title	2. Author
3. Date	4. Page
5. Project	6. Status
7. Review	8. Approval
9. Distribution	10. Special
A	

Approved for public release ;  
distribution unlimited.

This report summarizes the work carried out under AFOSR-79-0085

which commenced 1 January 1979 and ended 31 December 1980. Research was carried out in three main areas: constructive solution methods for integral equations arising in scattering problems, analysis of time dependent scattering phenomena, and applications of boundary control methods in radiation and scattering problems.

The results obtained under the grant have been presented at various national and international conferences and have resulted in a number of journal articles. A bibliography of these papers and presentations is appended.

Considerable progress has been made in the integral equation method applied to time harmonic scattering problems. Items 1-11 in the bibliography describe results obtained in this area. Item 2 surveys the present state of boundary integral equations with regard to time harmonic scattering by closed bounded objects. In addition to showing how many of the problems could be solved iteratively (items 1, 3, 6, 7) it was also shown how these results could be applied in some inverse problems (items 1, 5). Perhaps the most exciting development in this area has been in the use of modified Green's functions in boundary integral equations (items 8, 9, 10, 11). This work is ongoing but seems at this point to provide the extension of the iterative method of solution by guaranteeing convergence of the iterates for higher values of  $k$  than previously possible. Another notable result is the explicit determination of the behavior of the field in the neighborhood of

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a corner in the case of transition conditions at the boundary which is apparently a new result (3, 6).

The time dependent scattering work concentrated in two areas. A rigorous reformulation of the scattering problem for a body undergoing fairly general (non relativistic) motion, including, time dependent, shape distortions as well as rigid body motion, has been completed. The reformulation is in the form of an integral equation and the questions of existence and uniqueness of solutions of the reformulated problem are still under study. In the approximate-experimental approach work was completed on the case of periodic rigid body rotations through small angles. Good theoretical and experimental consistency was obtained (item 15) and a report describing this work is being completed.

The application of optimal control methods to radiation and scattering problems has proven to be very fruitful. In addition to further work on the radiation problem, that is, finding surface currents which optimize power radiated in given directions (item 13, 14) the impedance boundary value problem was recast as an optimal control problem in the following sense. The impedance was to be found which optimized the scattering cross-section in an angular region. (item 12) This led to consideration of the boundary integral equation formulation of the impedance problem and resulted in a rigorous derivation of the appropriate integral equations and a demonstration that they always had unique solutions (item 16, 17). Further work was done in the application of these optimal control methods to inverse scattering problems in which the shape of the

domain emerges as the optimal solution (items 13, 19, 20). This work shows considerable promise and is continuing.

## Publications and Presentations under [REDACTED]

1. The Direct and Inverse Scattering Problems for an Arbitrary Cylinder: Dirichlet Boundary Conditions, David Colton and Ralph Kleinman, Proc. Royal Soc. Edinburgh, 86A, 1980, 29-42.
2. Some Applications of Functional Analysis in Classical Scattering, R. E. Kleinman, in Mathematical Methods and Applications of Scattering Theory, J. A. DeSanto, A. W. Sáenz, and W. W. Zachary, ed., Lecture Notes in Physics 130, Springer-Verlag-Berlin-Heidelberg, New York, 1980.
3. Integral Equation Methods for Scattering by Penetrable Objects With Corners, R. E. Kleinman, Amer. Math. Soc. Annual Meeting, Bilox, Miss., January, 1979.
4. Applications of Fourier Transforms in Inverse Scattering, Amer. Math. Soc. Regional Meeting, R. E. Kleinman, Howard University, Washington, DC, October, 1979.
5. Inverse Scattering and the Born Approximation, R. E. Kleinman and B. D. Sleeman, North American Radio Science Meeting and IEEE/AP-S International Symposium, Québec, Canada, June, 1980.
6. Scattering by Triangular Cylinders, R. E. Kleinman and G. F. Roach, International URSI Symposium on Electromagnetic Waves, Munich, Federal Republic of Germany.
7. Integral Equation Methods in Scattering by Non Spherical Targets, R. E. Kleinman, 1980 CSL Scientific Conference on Obscuration and Aerosol Research, Chemical Systems Lab., Aberdeen Proving Ground, July, 1980.
8. Effect of Changes in Fundamental Solution on Singularities of the Resolvent, R. E. Kleinman, Conference on Mathematical Foundations of the Singularity Expansion Method, University of Kentucky, November, 1980.
9. On the Spectrum of Boundary Operators with Modified Green's Function for the Helmholtz Equation, R. E. Kleinman, Conference on Integral Equation Methods in Science and Engineering, Oberwolfach, Federal Republic of Germany, December, 1980.
10. Constructive Methods for Boundary Value Problems Depending on a Parameter, R. E. Kleinman and G. F. Roach, in Methods and techniques of Mathematical Physics, B. Brosowski and E. Martensen, eds., Proc. of Oberwolfach Conference, February, 1980, Verlag Peter D. Lang, Frankfurt 1981.



11. On Modified Green's Functions in Exterior Problems for the Helmholtz Equation, R. E. Kleinman and G. F. Roach, to be published.
12. Scattering Control by Impedance Loading, T. S. Angell and R. E. Kleinman, International URSI Symposium on Electromagnetic Waves, Munich, Federal Republic of Germany, August, 1980.
13. Operator-Theoretic and Computational Aspects of Ill-posed Problems in Antenna Theory, T. S. Angell and M. Z. Nashed, International Symposium on the Mathematical Theory of Networks and Systems, Vol. 3, P. Dewilde, ed., Delft University Press, Western Periodicals Co., Los Angeles, 1979.
14. Some Optimal Control Problems for the Helmholtz Equation, T. S. Angell, International Conference on Non-Linear Phenomena in Mathematical Sciences, University of Texas at Arlington, June, 1980.
15. Scattering by Rotating Oscillating Targets, R. E. Kleinman and R. B. Mack, North American Radio Science Meeting and IEEE/AP-S International Symposium, Québec, Canada, June, 1980.
16. Boundary Integral Equations for the Helmholtz Equation: The Third Boundary Value Problem, T. S. Angell and R. E. Kleinman, (to be published in Mathematical Methods in the Applied Sciences).
17. Scattering Control for the Robin Problem, T. S. Angell, Conference on Scattering Theory, Oberwolfach, Federal Republic of Germany, August, 1980.
18. Integral Equation Methods for Inverse Scattering, the Choice of Optimal Domain, T. S. Angell, Conference on Integral Equation Methods in Science and Engineering, Oberwolfach, Federal Republic of Germany, December, 1980.
19. Integral Equation Methods for Identification of a Scattering Domain, T. S. Angell, Rencontre R. C. P. Problems Inverses, Montpellier, France, December, 1980.
20. An Integral Equation Approach to Inverse Scattering, Identification of Domains, T. S. Angell, D. E. Colton, A. Kirsch, to be published.

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